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USE OF TEETH FOR AGE DETERMINATION OF SEALS AND OTHER MAMMALS

by

Christian Lydersen and Ian Gjertz

Fauna 39: 30-33,1985.

The objective of this article is to present the rationale for the use of teeth in age determination of mammals.Special emphasis has been placed on the age determination of seals, but most of the information is valid for most other mammals with annual rings in their dentin and cementum.

Exact age determination is an important criterion in understanding the many aspects of the life of an animal.This applies especially to growth rates, age at sexual maturity and life span. Age determinations are extensively used in the management of stocks of wild animals and therefore,a considerable amount of work has been done to develop methods for exact age determination.This applies especially to economically important species.

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In order to determine the absolute age of an animal there must be structures present whose growth is affected by regular events in the life of the animal.These structures, which are a result of discontinuities in the growth process, must be lasting and demonstrable.In mammals such growth zones are lasting and definable only in teeth and bones and occasionally in keratinized structures like horns and claws.

TOOTH ANATOMY AND PHYSIOLOGY

A mammal tooth consists of a crown and a root. The crown protrudes into the oral cavity, while the root is located in the dental alveoli in the jaw bone. The crown is covered with enamel on the outside, while the outside of the root is covered with cementum (Fig. 1). A newly emerged tooth is a thin-walled dentin cap with a crown already covered with enamel. Inside this cap there is soft tissue called dental pulp. This contains blood vessels and nerves and also the dentin-producing cells (odontoblasts). As the tooth grows, the dentin cap becomes thicker, the root is formed and cementum is being deposited on the outside of the root.Dentin is deposited from the tooth pulp so that the earliest dentin layers are situated closest to the outer wall of the tooth and the layers formed later closest to the pulp cavity. The cementum layer grows in thickness because new layers are being formed from the connective-tissue membrane (periodontium) which surrounds the root. The oldest cementum layers are therefore situated closest to the interphase between

dentin and cementum, while the newer layers are found closest to the cementum surface.

Dentin is a mineralized, fibrous, organic substance perforated by tubules. The organic material consists largely of collagen, with smaller proportions of citric acid, insoluble proteins, muco-polysaccharides and lipids (Scott and Symons 1977). The dentin tubules are protoplasmic protuberances from the odontoblasts, and they run parallel to each other from the outside of the dentin towards the pulp cavity. As long as dentin formation proceeds, the last formed layers on the pulp surface will be non-calcified and are called predentin. The inorganic material deposited during calcification will appear as spherical granules that are first segregated and later grow and fuse together. These granules called calcospherites. In those dentin areas where the calcospherites do not fuse together, a type of dentin called interglobular dentin is formed. When further mineralization occurs, the calcopherites get closer to each other, and the space between them, which consists of non-mineralized tissue, becomes smaller. A type of dentin called marble dentin is then formed.

The dentin formation occurs rhythmically, i.e., in p.?1
alternating stages of growth and rest (Scott and Symonds 1977). In those parts of the dentin where this occurs, so-called growth zones are formed. In teeth where calcification starts before birth, there is a clearly defined line in the dentin, which

separates that formed before and after birth. This line is called the neo-natal line and it is caused by changes in the nutrition and outer environment of the animal.

When the tooth appears in the oral cavity, it is largely only the dentin in the crown that has been formed (primary dentin). Later, dentin is formed in the root part, which gradually leads to a reduction in the size of the pulp cavity. This type of dentin which is deposited slowly with increasing age and leads to a reduction in the size of the pulp cavity, is physiologically secondary dentin.

Cementum is also a mineralized, fibrous, organic substance similar to bone tissue with respect to components, structure and behavior. The main purpose of cementum is to fasten teeth to alveolar bones in the jaw and to act as a buffer against loosening and blows especially during the growth of the teeth (Scott and Symonds 1977).

TEETH AND AGE DETERMINATION

The most accurate method available today for determining the absolute age of mammals is to count growth zones in cementum and dentin in teeth and/or in the periosteal zone in bones. Klevezal and Kleinenberg (1967) are of the opinion that this methodology is practically the only one that makes it possible to determine the ages of both young and old animals of both sexes with a margin of error of only one year.

Already in the last century, Owen (1840) described concentric layers in dentin and cementum in the teeth of toothed whales and concentric rings parallel with the pulp cavity in the teeth of seals.

Eidman (1932) used lines in the dentin , which he demonstrated to be annual, to determine the age of the deer Cervus elaphus L. 1758. He expected to find such lines both in herbivorous and carnivorous mammals which have periodic changes in food uptake.

Scheffer(1950) and Laws(1952) published independently of each other, methods for age determination of seals. Scheffer studied the canine teeth of the northern fur seal Callorhinus ursinus L. (1758) in individuals whose ages were known from tagging experiments. He found concentric elevations around the roots of the teeth and that the ages of the animals corresponded to the number of these. Laws developed a new method for age determination when he worked with the southern elephant seal Mirounga leonina L. (1758). This method was dependent on cyclic variations in the deposition of calcium in the teeth of the animals. In cross sections of the canine teeth, he found layered structures where each layer consisted of two zones of dentin with differing optical density. A dentin layer like this was being formed each year, so that the number of layers was equal to the age of the animal in years.

The studies by Scheffer(1950) and Laws(1952) led to a number of studies of teeth from other species of marine mammals.

By 1967, layers of cementum and dentin as age indicators had been described for 21 seal species (Klevezal and Kleinenberg 1967).

The milk-teeth are very poorly developed in all seal species (King 1964). In the family Phocidae which includes all seal species occurring in Norwegian waters except for the walrus Odobenus rosmarus rosmarus L. (1758), milk-teeth are resorbed before birth or they drop just after birth. Walrus loses its milk teeth just after birth. This means that age counted from a section of a permanent tooth from a seal corresponds to the actual age of the animal.

The growth zones in both dentin and cementum consist of a wide and a narrow band with different optical densities or color intensities, in decalcified stained sections. "Dense", "thin", "light", "dark", "columnar", "marbled", "opaque" and "translucent" are used in the literature to characterize a growth zone, depending on how the tooth is prepared and examined; i.e., whether stained decalcified sections or non-decalcified sections are examined with reflecting or transmitting light.

In the following, the usually widest band which is darkest if examined with transmitting light and which is lightest when examined with reflecting light, will be called opaque. The usually narrowest band with the opposite optical properties will be called translucent.

Relative calcium content in respectively opaque and translucent bands is discussed by a number of authors. Laws(1953), Fisher(1954) and McLaren(1958) are of the opinion

that the opaque band is hypercalcified, while Oshumi et al (1963) and Klevezal and Kleinenberg(1967) feel that the translucent band is hypercalcified. Klevezal and Kleinenberg(1967) state that the translucent bands both in dentin and in cementum are hypercalcified because this band is most strongly stained with hematoxylin and silver nitrate; i.e., that these stains react strongest with well calcified tissues. Sergeant(1969) also feels that translucent bands are hypercalcified, based on his own microradiographic studies of tooth sections. However, Best(1970) has shown that neither hematoxylin nor silver nitrate are specific for calcium and that the use of these stains as quantitative indicators of differences in calcium content is not tenable. He assumes that the optical differences in the two p.32 bands are due to a factor other than differences in the degree of calcification. Smith(1973) is in agreement with this, since it has never been proven that differences in calcium content are the reason for the opaque/translucent properties of dentin.

There is also an ongoing discussion between various authors on the reason for the discontinuous manner dentin and cementum are being deposited. Laws(1953) lists fasting, variations in the vitamin D content or changes in parathyroid activity as possible factors. Fisher(1954) found that the harp seal Phoca groenlandica(Erxleben,1777) deposited translucent dentin in the period of minimal food uptake connected with pupping, mating and moulting. He claimed that the main source of vitamin D for this seal species is found in the food eaten, and

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that translucent dentin was therefore deposited in the fasting period. Carrick and Ingram(1962) found that the southern elephant seal deposit opaque dentin under a number of differing environmental and physiological conditions. These are not necessarily related to the animal's being ashore or in the water, or the mating season or moulting period. The food of this seal is rich in vitamin D, phosphorus and calcium, and the fact that a female could deposit opaque dentin in the fasting period while suckling its pup, shows that it is not the lack of essential nutrients that is decisive. Laws(1953) pointed out that increased solar radiation while elephant seals are ashore could be necessary to achieve a vitamin D level high enough for deposition of opaque dentin. Carrick and Ingham(1962) thought that the effect of the sun was strong enough even when the animals were in the water, since opaque dentin was being formed even then. They also point out that many elephant seals are covered with mud when they are ashore so that this screens the radiation from the sun. They propose that secretion of adrenalin or other endocrine activity in connection with stress can be the necessary stimulus. They also point out that the formation of the two types of dentin is possibly controlled by different physiological mechanisms in Phoca and Mirounga.

No resorption of mineralized material occurs in dentin and cementum so that both keep all annual rings throughout the life of the animal (Klevezal and Kleinenberg 1967). Growth zones in dentin are especially prominent in stained teeth sections, but

there are differing opinions about their suitability for age determination (Morris 1978).For example, Mansfield and Fisher (1960) and Hewer(1960) studied teeth from respectively harbour seal, Phoca vitulina L. 1758 and grey seal Halichoerus grypus (Fabricius,1791) of known ages. In both studies it was established that the dentin zones were not countable while the growth zones in the cementum layer represented year rings. Secondary dentin often contains several zones(accessory growth lines) in addition to the yearly zones.These have no connection with the age of the animal and make counting more difficult. In addition, the deposition of secondary dentin is limited by how much space is available before the pulp cavity is filled.An example is the ringed seal Phoca hispida Schreber 1775, in which the pulp cavity is filled when the animal is 22-24 years old (Klevezal and Kleineberg 1967). Older ringed seals cannot be aged by dentin counting, while counting of cementum zones has shown that seals of this species can be up to 45 years old (Lydersen 1983). Age determination by counting annual rings in the cementum is not, to the same extent as dentin counts, made more difficult by accessory growth lines.The cementum is also deposited on the outside of the tooth, and growth is not limited by space restrictions. These two factors have resulted in that countings based on the cementum are, the most commonly used method for age determination of mammals (Morris 1978, Grue and Jensen 1979)

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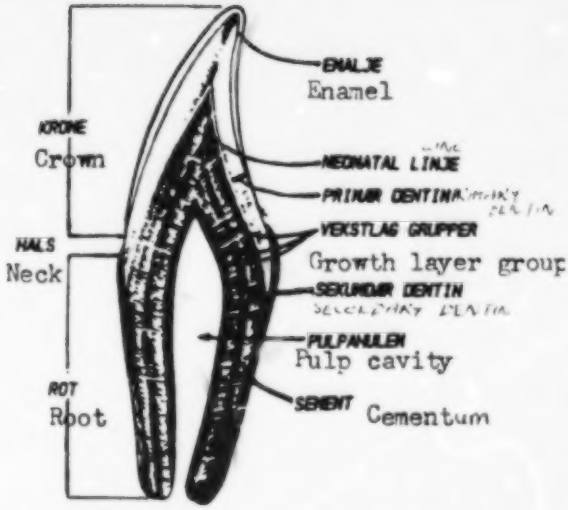

Fig. 1. Lengdesnitt av en tann. Etter Perrin & Myrrick (1980).
Longitudinal section of a tooth.

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ABSTRACT

Lydersen, C. & Gjertz, I. 1986. The use of teeth for age determination of mammals with special reference to seals. *Fauna 39*, 30–33.

A general review on tooth anatomy and physiology with special reference on the layered structure in dentine and cementum, is presented. A brief summary of the discussion among different authors concerning the relative concentrations of calcium in opaque and translucent sones of dental layers is included, and reasons for the discontinous growth of dentine and cementum is discussed.

Age determination by reading annual layers in cementum is not as affected as dentine of accessory growth lines. There is furthermore no space limitations to the growth of cementum layers. These are the reasons why today reading annual layers in the cementum is the most frequently used method for age determination of mammals.

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